ON THE INTERPRETATION AND STATUS OF SOME HYSTRICHOSPHERE GENERA

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ABSTRACT. The taxonomic status of the genera *Micrhystridium*, *Baltisphaeridium*, *Veryhachium*, *Multiplicisphaeridium*, *Leiosphaeridia*, *Leiosphaeridium*, *Protoleiosphaeridium*, and *Archaeohystrichosphaeridium* is examined. The generic names *Multiplicisphaeridium*, *Leiosphaeridium*, and *Protoleiosphaeridium* are rejected: the genera *Micrhystridium*, *Baltisphaeridium*, *Leiosphaeridia*, and *Veryhachium* are redefined: and lists are given of the species now considered to belong to these genera, the generic attribution of 140 species being changed.

IN his recent paper describing assemblages of Devonian microplankton from Alberta, Canada, F. L. Staplin (1961) has made a number of proposals relating to the taxonomy of the hystrichospheres which we consider not acceptable. These proposals have been briefly criticized by Eisenack (1962); they are here discussed fully and the reasons for their rejection are outlined. The status of the genera concerned and of some related genera is examined and the attribution of species to these genera is clarified.

1. *Micrhystridium—Baltisphaeridium*

Deflandre (1937) erected the genus *Micrhystridium* to include all globular hystrichospheres having a shell diameter generally less than 20 μ, regardless of the character of their appendages: he designated as type species *Micrhystridium inconspicuum* (Deflandre 1935), a form having thorn-like processes with closed tips. The distinction between this genus and the genus *Hystrichosphaeridium*, erected in the same paper, lay only in dimensions, *Hystrichosphaeridium* then comprising all forms whose shells were not differentiated into fields by sutures, again regardless of appendage character. In 1958 this latter genus was split by Eisenack, who, retaining the name *Hystrichosphaeridium* for forms which, like the type *H. tubiferum* (Ehrenberg 1838) Deflandre 1937, possess tubular spines open distally, erected a new genus, *Baltisphaeridium*, for forms having spines closed distally, the type species being *B. longispinosum* (Eisenack 1931). No alteration was made to the diagnosis of *Micrhystridium*.

Staplin proposes the abolition of the upper size limit for *Micrhystridium* and a redefinition of the genus on the basis of the spine character of its type species, causing it to correspond exactly with *Baltisphaeridium*. On this basis he proposes abandonment of the latter genus and the reattribution of its species to *Micrhystridium*.

The hystrichospheres having spines closed distally exhibit an overall range in shell diameters from 5 μ to 240 μ. Consideration of the size ranges of individual species reveals two major groupings, two foci of morphology: this has been graphically represented by Downie (1958, p. 334) in an analysis of a Tremadocian hystrichosphere assemblage. The boundary between these two major groupings has been accepted by most workers as being sensibly drawn at 20 μ. While species exist which overlap this boundary from either side, the number of species having a size mode between 20 and 25 μ is very small: of 204 Palaeozoic species and infraspecific groups attributable to the genera

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Micrhystridium and *Baltisphaeridium* (186 species and 18 infraspecies), only 10 overlap the boundary and only 1, *B. ramusculosum* (Deflandre 1942), has a size mode actually on the boundary. Of 164 Mesozoic and Tertiary species and infraspecific groups attributable to the genera *Micrhystridium* and *Baltisphaeridium* (117 species and 46 infraspecies and forms related to named species), only 8 overlap the boundary and only one, *M. piliferum* (Deflandre 1937), apparently has a size mode actually on the boundary: this species is based on a single specimen. (Size ranges are quoted in detail in the accompanying systematic section.) The few forms transgressing the size boundary separating the genera may be regarded as extremes in series surrounding morphological foci: transgressions of the boundary are usually slight and by extremes in the size range of a particular species whose mode is clearly below or above the boundary.

The forms having a shell diameter smaller than 20 μ, the micrhystridia, appear at many horizons in the Upper Palaeozoic and Mesozoic (Carboniferous, Permian, Triassic, and Jurassic) to correspond in their concentration to differences in environment, tending to be either very abundant or extremely few in number in particular assemblages.

Although Staplin's emendation of the genus *Micrhystridium* may be legally valid in terms of the existing Codes of Nomenclature, his proposal to remove from the diagnosis the one distinguishing characteristic specified by its author renders the genus meaningless: to do so would be to make it synonymous with *Hystrichosphaeridium* as defined at the time of publication of the two generic diagnoses. We consider that the genera *Micrhystridium* and *Baltisphaeridium* express two natural size modes, and that the size boundary separating them should be retained at least until more compelling evidence for emendation of the genera is available.

We feel, however, that the genus *Micrhystridium*, as at present defined, is rather heterogeneous, since it comprises not only forms having processes with simple tests, not divided into fields by crests, and with simple spines closed distally, but also forms whose shells are divided into fields and others that have processes open distally. We consider with Staplin that it should be restricted to forms having spines with closed tips: that forms having shells whose surfaces are divided into fields by crests should be transferred to the genus *Cymatiosphaera* and forms having tubular processes to the genus *Hystrichosphaeridium*. If in the future it transpires that within the two latter genera there exists a similar division into natural size modes, new taxa may then be erected to express this difference.

2. *Veryhachium*

The name *Veryhachium* was introduced in 1954, being applied to a species, *V. trisulcum*, which was not at that time validly published. This was subsequently rectified in 1958 and the genus should date from then. The genus was emended by implication by one of us (Downie 1959) when forms with an ellipsoidal test and a single spine were removed to a new genus, *Deunffia*. *Veryhachium* then included hystrichospheres with polygonal tests and a small number of spines. In recent publications (Eisenack 1959, Staplin 1961), markedly contrasted interpretations of the genus have been evident and we consider a clarification of the situation necessary.

It is evident from recent publications (Eisenack 1959, Jekhowsky 1961) that morphological transitions exist between *Veryhachium* and both *Micrhystridium* and *Baltiphaeridium*. Eisenack (p. 207) recognizes these difficulties and prefers to retain in

Baltisphaeridium any polygonal form which, by other morphological criteria, is linked to typically round-bodied forms, e.g. *B. oligospinosum* and *B. visbyense*, which accord in all respects with the diagnosis of *Veryhachium*. He rightly states that the generic boundary would otherwise separate forms that are closely related.

The principle that Eisenack is enunciating, that taxonomic units should express natural relationships, is one with which the authors are in general agreement. However, rigid application of this principle to the hystrichospheres would result in the shrivelling or disappearance of most existing genera, with a resultant vast increase of species within the few remaining (*Micrhystridium* emend. Staplin would, for example, contain about 800 species). It would, moreover, produce a false picture of the real situation where, although overlap and gradation may occur at the fringes, there do exist morphological groupings with intermediates considerably rarer than typical forms. Even Eisenack does not apply his principle rigorously, for he has several times emphasized the existence of continuous gradation between leiospheres and hystrichospheres, and yet separates them into distinct genera.

We consider that the generic name *Veryhachium* should be applied to forms having a low number (generally 3–8) of hollow spines arising from a polygonal or subpolygonal test. The combination of shell shape and spine number is considered to define the genus, and the views of Staplin, that all species having a polygonal test should be placed within this genus, regardless of spine number, are rejected as contrary to the original intention of Deunff.

3. *Dorsatosphaera*

The status of this genus and of related genera erected by Timofiev (1959) has been recently reviewed by Deflandre and Deflandre-Rigaud (1961). The decisions of these authors are accepted in their entirety, and their paper is welcomed for its clarification and regularization of a potentially difficult taxonomic situation.

4. *Multiplicisphaeridium*

This proposed new genus (Staplin 1961) is distinguished from *Baltisphaeridium* and *Micrhystridium* in the character of the spine tips: forms having unmodified spine tips are referred to the two latter genera, while forms having multifurcate, expanded, or dissected spine tips are referred to *Multiplicisphaeridium*. The number of species that would be referable to this latter genus in the Palaeozoic is not large (20 species, at present allocated to the genera *Micrhystridium*, *Baltisphaeridium*, and *Archaeohystrichosphaeridium*), but in the Mesozoic and Tertiary it is considerable.

Multiplicisphaeridium is considered morphologically ill-founded for the following reasons:

(*a*) While many species do have entirely simple or entirely complex spine tips, there are a number of species whose representatives consistently have both simple and furcate, or complex, spine tips.

(*b*) In some individual species, the normal range of variation includes specimens with only simple spines, specimens with only furcate, &c., spines, and specimens with spines of mixed types.

(*c*) The species having in common the character of furcate, &c., spine tips show no

distinctive combinations of other characters to suggest that they constitute a morphologically separate entity. Examination of assemblages at the same or earlier horizons frequently discloses a higher degree of morphological similarity to species with unbranched spines than to other species of *Multiplicisphaeridium*. There is no evidence for the view that *Multiplicisphaeridium* constitutes an evolutionary chain of species; on the contrary, there is much evidence that the species with furcate or complex spine tips repeatedly arose, by a trend of increasing spine complexity, from forms with simple spines.

(*d*) When combinations of other characters are brought into account, there are seen to be a number of groupings within *Baltisphaeridium* as here defined; species within these groupings may have simple, furcate, or complex spines. Separation of forms having spines of the two latter types into a distinct genus would cut across these groupings and would obscure natural relationships.

In the Palaeozoic, a series of increasing spine complexity is clearly shown in two cases: *Baltisphaeridium polygonale* (Eisenack 1931)→*B. digitatum* (Eisenack 1938); Ordovician. *B. oligofurcatum* (Eisenack 1954)→*B. meson* (Eisenack 1955)→*B. brevifurcatum* (Eisenack 1954); Silurian. Other Palaeozoic species having intermediate characters are listed below.

(*a*) Species having both simple spines and knobbed, bi- or trifurcate spines.

ORDOVICIAN. *Baltisphaeridium longispinosum* (Eisenack 1931) Eisenack 1958; *B. nudatum* (Timofiev 1959) comb. nov; *B. ordovicum* (Timofiev 1959) comb. nov; *B. rjabinini* Timofiev 1959) comb. nov.

SILURIAN. *B. ranusculosum* (Deflandre 1942), Downie 1958.

DEVONIAN. *B.* cf. *digitatum* (Deunff 1954) comb. nov.

(*b*) Species having only briefly furcate spines.

ORDOVICIAN. *B. circumscissum* (Timofiev 1959) comb. nov; *B. setigerfurcatum* (Timofiev 1959) comb. nov.

DEVONIAN. *B. lewisi* (Deunff 1954) comb. nov.; *B. microfurcatum* Deunff 1957.

A large number of Mesozoic and Tertiary species show intermediate characteristics:

(*a*) Species having both simple spines and knobbed, bi- or trifurcate spines.

JURASSIC. *Baltisphaeridium polytrichum* sensu Downie 1957 non Valensi 1947; *B. varispinosum* Sarjeant 1959; *B.* cf. *multifurcatum* (Deflandre 1947), Klement 1960; *B. lunectum* Sarjeant 1960*a*; *B.* cf. *fimbriatum* (White 1842), Sarjeant 1960*a*.

CRETACEOUS. *B. multifurcatum* (Deflandre 1937) Klement 1960; *B. pseudhystrichodinium* (Deflandre 1937) comb. nov.; *B. striolatum* (Deflandre 1937) comb. nov.; *B.* cf. *pseudhystrichodinium* (Deflandre 1937), Lejeune-Carpentier 1941; *B. longifurcatum* (Firtion 1952) comb. nov.; *B.* cf. *striolatum* (Deflandre 1937), W. Wetzel 1952; *B. oligacanthum* (W. Wetzel 1952) comb. nov. and its subspecies.

EOCENE. *Micrhystridium* cf. *stellatum* Deflandre 1942, Deflandre and Cookson 1955; *Baltisphaeridium geometricum* (Pastiels 1948) comb. nov.

OLIGOCENE. *B.* cf. *pseudhystrichodinium* (Deflandre 1937), Gocht 1952.

(*b*) Species having simple spines together with others of complex form.

JURASSIC. *Baltisphaeridium vestitum* (Deflandre 1938) Sarjeant 1960*b*.

CRETACEOUS. *B. flosculus* (Deflandre 1937) comb. nov.; *B. horridum* (Deflandre 1937) comb. nov.; *B. heteracanthum* (Deflandre and Cookson 1955) comb. nov.; *B. tridactylites* (Valensi 1955) comb. nov.

(*c*) Species having capitate (c.), knobbed (k.), or only briefly furcate (f.) spines.

JURASSIC. *Baltisphaeridium* cf. *intermedium* (O. Wetzel 1933), Deflandre 1938 (f.); *Micrhystridium bigoti* Deflandre 1947 (f.); *M. variabile* Valensi 1953 (c. or f.); *B. downiei* Sarjeant 1960*a* (c., k., or f.); *B.* aff. *fimbriatum* (White 1842), Sarjeant 1960*b* (f.); *B. tribuliferum* Sarjeant 1962*b* (f.); *M. rhopalicum* Sarjeant 1962*b* (k. or f.).

CRETACEOUS. *Baltisphaeridium fimbriatum* (White 1842), Sarjeant 1960*b* (f.); *B. intermedium* (O. Wetzel 1933) comb. nov. (f.); *B.* aff. *multifurcatum* (Deflandre 1937), Firtion 1952; *B. rhabdophorum* (Valensi 1955) comb. nov. (f.); *B. huguonioti* (Valensi 1955) comb. nov. (f.).

EOCENE. *B. colligerum* (Deflandre and Cookson 1955) comb. nov. (c. or f.).

OLIGOCENE. *B. longofilum* (Maier 1959) comb. nov. (f).; *B. echinoides* (Maier 1959) comb. nov. (c.).

There are thus a considerable number of species whose spine characters indicate a morphogenetical position between forms having wholly simple spines and forms having multifurcate, expanded, or dissected spines all of one type. The use of the structure of spine tips cannot be considered a satisfactory single criterion for determining generic assignment; the genus *Multiplicisphaeridium* would, if accepted, be an agglomeration of end members of numerous evolutionary trends rather than the focus of a morphological grouping. All, or nearly all, existing genera have been established in the view that they have genetic meaning and express natural groupings: the discovery of overlap with other genera at the extreme limits of their morphological spread does not necessarily invalidate this view. In the case of *Multiplicisphaeridium*, such a view cannot be held even at the inception. We propose therefore that this genus be abandoned and that the present distribution into genera of the species comprising it be retained.

5. *The leiospheres*

The generic name *Leiosphaeridium* Timofiev apparently first appeared in a caption to an illustration (1956) and was not therefore validly published until 1959, when a description was given. (Figures unaccompanied by diagnoses do not constitute valid publication either under the Botanical or Zoological Rules at this date.) It was intended as an alteration of *Leiosphaera* Eisenack (1938) and as such it is invalid. The type species of the genus *Leiosphaera*, *L. solida*, was recognized by Eisenack (1958) as conspecific with *Tasmanites huronensis* (Dawson 1871); he thus abandoned the genus, attributing to *Tasmanites* such species as accord with its diagnosis and setting up a new genus, *Leiosphaeridia*, to accommodate forms not attributable to *Tasmanites*. The name *Leiosphaeridium* was proposed as an amendment of *Leiosphaera* and presumably Timofiev regarded *L. solida* as its type species; *Leiosphaeridium* is thus a junior synonym of *Leiosphaera* and hence of *Tasmanites*. If the single species attributed to *Leiosphaeridium* by Timofiev were considered as its type, its characters are such as to render it attributable

to *Leiosphaeridia*, of which the genus then becomes a junior synonym. Whichever viewpoint is taken, the name *Leiosphaeridium* must be abandoned. It is clear that at the time of writing, Timofiev was not aware of the existence of the genus *Leiosphaeridia*.

The genus *Protoleiosphaeridium* Timofiev was likewise not validly published until 1959 and its type species, *P. conglutinatum*, was not so designated until 1960. The size ranges quoted for this genus and for *Leiosphaeridium* are 20–30 μ and 200–300 μ: these size ranges are confusing, since the six species attributed by Timofiev to the former genus have a range 20–50 μ and the single species attributed to the latter genus has a size range of 100–125 μ.

While the name *Leiosphaeridium* cannot be retained, whether in the original meaning of Timofiev or under the amended diagnosis of Staplin (rejected names cannot be re-used under either the Zoological or the Botanical Rules), *Protoleiosphaeridium* might be retained as a subgenus of *Leiosphaeridia* and restricted to thin-walled forms having a diameter less than 50 μ. The type of Eisenack's genus has a size range 80–140 μ: however, the total range size of all species attributed to this genus is 23–150 μ and there is no indication of any division into size modes. We feel that *Protoleiosphaeridium* should be treated as a synonym of *Leiosphaeridia* and rejected, and that its species should be reattributed to the latter genus.

The statement in Eisenack's diagnosis that a pylome exists in *Leiosphaeridia* is to be interpreted as indicating that this is a structure present in some species but not in all. He does not even consider possession of a pylome to be a factor of specific value (Eisenack, *in litt.*).

Timofiev (1959) also established seven other genera in the family Leiosphaeridiaceae. Of these, *Vavososphaeridium* (reticulate ornament), *Orycmatosphaeridium* (pitted surface), *Lophosphaeridium* (tubercular ornament), and *Trachysphaeridium* (shagreen ornament) might be considered subgenera of *Leiosphaeridia* based on different shell ornament. Some of the species listed under *Leiosphaeridia* could probably be attributed to one or other of these subgenera: however, without examination of type material, the authors do not feel competent to make such reallocation. Timofiev's other genera *Zonosphaeridium* (thick walls), *Trematosphaeridium* (perforate test), and *Symplassosphaeridium* (clusters of vesicles) seem either to be the product of accidents of preservation or to be quite different kinds of structure from the typical leiospheres: judgement on them is, for the present, reserved, although the considerable resemblance between *Zonosphaeridium* (thick walls: ? = *Tasmanites*) and the genus *Tasmanites* may be noted.

6. *Archaeohystrichosphaeridium*

Staplin does not consider this genus of Timofiev (1959) in his taxonomic review. The genus was defined as follows: 'Vesicle with diameter 10–35 μ, thin, ornamented with simple, blunt, or pointed spines, sometimes forking on the periphery. Colour pale yellow.'

The range of diameters quoted by Timofiev is in fact 18–70 μ: only ten of seventy-nine species so far attributed to it fail to exceed 35 μ. No type species has yet been designated, so that the genus has not yet been validly published. As at present defined, the genus is indistinguishable from *Baltisphaeridium* Eisenack and may be by intent a synonym of that genus. The thinness of the shell walls might afford a basis for differentiation at subgeneric level. The authors have not reattributed the species of *Archaeohystricho-*

sphaeridium here, since they hope that a validation and redefinition of the genus may be forthcoming.

SYSTEMATIC SECTION

Evitt (1961) has recently drawn together evidence concerning the relationships of the hystrichospheres and has demonstrated the presence in many genera and species, though by no means in all, of structures indicating relationship to the dinoflagellates. In particular he has shown that the genus *Hystrichosphaera*, on which the Order Hystrichosphaeridea is based, is attributable to the Dinophyceae. A reclassification of the hystrichospheres, following this work, is at present in preparation; for the present, classification is made to generic level only. Known range of shell diameters is quoted for the species of *Micrhystridium* and *Baltisphaeridium*: where species are reallocated to these genera, they were previously in *Hystrichosphaeridium* unless otherwise stated.

The authors would like to emphasize that species have been attributed to the various genera on the basis of published descriptions and allocations, and that the inclusion of a species name does not necessarily imply endorsement of its status. Some of the species included differ morphologically only slightly, if at all, from others previously described; others, e.g. those of Sannemann (1955) here attributed to *Baltisphaeridium*, probably constitute distinct genera whose definition is not possible on present knowledge.

Genus BALTISPHAERIDIUM Eisenack 1958, emend.

Emended diagnosis. Hystrichospheres with spherical to oval shells not divided into fields or plates, bearing ± numerous processes, simple, branching or ramifying, hollow to solid, always with closed tips. The processes are not connected together distally and no outer shell, complete or incomplete, is present: the processes are most often of a single basic type, but processes of two or more types may be present. Mean and modal diameter of shell greater than 20 μ.

Discussion. While the spines of species attributed to *Baltisphaeridium* and *Micrhystridium* are most often hollow, some or all spines of particular species may be partly or wholly solid. The hollowness or otherwise of the spines is extremely difficult to determine in many instances, particularly in species of *Micrhystridium*. On a single specimen, spines may be in part hollow, in part solid; Evitt (*in litt.*) notes that this is the case in *B. ferox* and in *B. flosculus*. Species occur whose spines are hollow throughout their length and closed only at the tip; others with spines solid for most of their length, but with a cavity at the base. Sannemann (1955) has described a number of species in which there is a solid central 'spire' within the spine cavity. The importance of distinguishing between these alternatives is doubtful; for the present, no such distinction is made.

Type species. Baltisphaeridium longispinosum (Eisenack 1931) Eisenack 1958 (40–75 μ); Cambrian–Ordovician.

Other species (*Palaeozoic*). *Baltisphaeridium aculeatum* (Timofiev 1959) comb. nov. (70–90 μ); *B. alloiteaui* (Deunff 1955) comb. nov. (formerly *Micrhystridium*) (25–30 μ); *B. annulatum* (Timofiev 1959) comb. nov. (93–96 μ); *B. apiculatum* (Timofiev 1959) comb. nov. (50–60 μ); *B. arrectum* (Timofiev 1959) comb. nov. (70–100 μ).

B. binarginatum (Timofiev 1959) comb. nov. (60–80 μ); *B. bohemicum* (Eisenack 1934) comb. nov. (120 μ); *B. brevifurcatum* (Eis. 1954) comb nov. (60 μ); *B. brevispinosum* (Eis. 1931) Eisenack 1958

(50–70 μ); *B. brevispinosum* (Eis. 1931) subsp. *callosum* Sannemann 1955 (200 μ); *B. brevispinosum* (Eis. 1931) subsp. *castaneioides* Sannemann 1955 (200 μ); *B. brevispinosum* (Eis. 1931) var. *granulifera* Downie 1959 (16–32 μ); *B. brevispinosum* (Eis. 1931) var. *nanum* Deflandre 1942 (25–26 μ); *B. brevispinosum* (Eis. 1931) var. *wenlockensis* Downie 1959 (16–32 μ); *B. breviciliatum* (Staplin 1961) comb. nov. (formerly *Micrhystridium*) (32–37 μ).

B. castaneum (Eisenack 1934) comb. nov. (150–160 μ); *B. circumscissum* (Timofiev 1959) comb. nov. (70–90 μ); *B. cognitum* (Timofiev 1959) comb. nov. (50–100 μ); *B. coniferum* (Sannemann 1955) comb. nov. (340 μ); *B. conspicuum* (Timofiev 1959) comb. nov. (106–109 μ); *B. corallinum* Eisenack 1959 (70–95 μ); *B. corollatum* (Timofiev 1959) comb. nov. (91–99 μ); *B. crassiechinatum* (Staplin 1961) comb. nov. (formerly *Micrhystridium*) (24–33 μ); *B. cristatum* (Downie 1958) Eisenack 1958 (23–30 μ).

B. differtum (Sannemann 1955) comb. nov. (250 μ); *B. digitatum* (Eisenack 1938) Eisenack 1959 (65–75 μ); *B. dignum* (Sannemann 1955) comb. nov. (150 μ); *B. diploporum* (Eis. 1951) comb. nov. (formerly *Micrhystridium*) 35–40 μ).

B. echinosum (Staplin 1961) comb. nov. (formerly *Micrhystridium*) (17–22 μ); *B. eisenackium* (Deunff 1958) comb. nov. (60 μ); *B. eisenackium* (Deunff 1958) var. *crozonensis* Deunff 1958 (25 μ); *B. eisenacki* (Sannemann 1955) comb. nov. (125 μ); *B. eoplanktonicum* (Eisenack 1955) Downie 1959 (20 μ); *B. erraticum* (Eis. 1954) comb. nov. (35–50 μ); *B. franconium* (Sannemann 1955) comb. nov. (200 μ); *B. gotlandicum* (Eis. 1954) comb. nov. (46 μ).

B. hippocrepicum (Timofiev 1959) comb. nov. (69–78 μ); *B. hirsutoides* (Eisenack 1939 emend. Eisenack 1951) Eisenack 1958 (20–50 μ); *B. hirsutoides* (Eis. 1939 emend. Eis. 1951) var. *hamatum* Downie 1958 (18–40 μ); *B. hymenoferum* (Eis. 1938) Eisenack 1958 (65 μ); *B. hystrichoreticulatum* (Eis. 1938) comb. nov. (40–45 μ); *B. inconspicuum* (Timofiev 1959) comb. nov. (45–65 μ); *B. integrum* (Sannemann 1955) comb. nov. (300 μ).

B. lewisi (Deunff 1954) comb. nov. (45 μ); *B. longispinosoides* (Sannemann 1955) comb. nov. (120–200 μ); *B. longispinosum* (Eisenack 1931) forma *filifera* Eisenack 1959 (40–75 μ); *B. longispinosum* (Eis. 1931) forma *latiradiata* Eisenack 1959 (40–75 μ); *B. longispinosum* (Eis. 1931) forma *robusta* Eisenack 1959 (40–75 μ); *B. lophophorum* Eisenack 1959 (30 μ); *B. lucidum* (Deunff 1958) comb. nov. (80–89 μ).

B. macropylum Eisenack 1959 (60–68 μ); *B. meson* (Eis. 1955) comb. nov. (54–62 μ); *B. micracanthum* Eisenack 1959 (68–88 μ); *B. microfurcatum* (Deunff 1957) comb. nov. (22 μ); *B. microspinosum* (Eis. 1954) Downie 1959 (58 μ); *B. multipilosum* (Eis. 1931) Eisenack 1958 (45–60 μ); *B. multipilosum* (Eis. 1931) subsp. *validum* Sannemann 1955 (130–180 μ); *B. mutabile* (Sannemann 1955) comb. nov. (150 μ); *B. nudatum* (Timofiev 1959) comb. nov. (66–69 μ).

B. octospinum (Staplin 1961) comb. nov. (formerly *Micrhystridium*) (24–33 μ); *B. oligofurcatum* (Eisenack 1954) comb. nov. (56 μ); *B. ordovicum* (Timofiev 1959) comb. nov. (80–84 μ); *B. pateum* (Timofiev 1959) comb. nov. (60–100 μ); *B. paucispinum* (Deunff 1954) comb. nov. (formerly *Veryhachium*) (24–28 μ); *B. piriferum* (Eis. 1954) comb. nov. (62 μ); *B. polygonale* (Eis. 1931) Eisenack 1959 (75–230 μ); *B. quadriradiatum* (Timofiev 1959) comb. nov. (93–106 μ).

B. ramispinosum (Staplin 1961) comb. nov. (formerly *Multiplicisphaeridium*) (19–29 μ); *B. ramusculosum* (Deflandre 1942) Downie 1959 (18–23 μ); *B. ramusculosum* (Defl. 1942) var. *macrocladum* Deunff 1955 (30 μ); *B. rigens* (Timofiev 1959) comb. nov. (90–100 μ); *B. rjabinini* (Timofiev 1959) comb. nov. (58–70 μ); *B. robustispinosum* Downie 1959 (30 μ); *B. robustum* (Sannemann 1955) comb. nov. (240 μ); *B. robustum* (Sannemann 1955) subsp. *fissum* Sannemann 1955 (15 μ).

B. sannemanni (Deunff 1958) comb. nov. (formerly *Micrhystridium* (24 μ); *B. sedecimspinosum* (Staplin 1961) comb. nov. (formerly *Veryhachium*) (19–25 μ); *B. sericum* (Deunff 1954) comb. nov. (formerly *Micrhystridium*) (23–26 μ); *B. setigerfurcatum* (Timofiev 1959) comb. nov. (81–84 μ); *B. sexradiatum* (Timofiev 1959) comb. nov. (55–60 μ); *B. spicatum* (Staplin 1959) comb. nov. (formerly *Multiplicisphaeridium*) (63–72 μ); *B. spiciferum* (Deunff 1955) comb. nov. (23–31 μ); *B. spiniscens* (Timofiev 1959) comb. nov. (80–110 μ); *B. spinoglobosum* (Staplin 1961) comb. nov. (formerly *Micrhystridium*) (17–24 μ); *B. sprucegrovensis* (Staplin 1961) comb. nov. (formerly ? *Multiplicisphaeridium*) (35–44 μ); *B. stellaeforme* (Timofiev 1959) comb. nov. (88–99 μ); *B. suecicum* Eisenack 1959 (50–67 μ).

B. timofeevi Deunff 1961 (25–30 μ); *B. trifurcatum* (Eisenack 1931) Eisenack 1958 (50–70 μ); *B. trifurcatum* (Eis. 1931) forma *breviradiata* Eisenack 1959 (70 μ); *B. trifurcatum* (Eis. 1931) forma *longiradiata* Eisenack 1959 (45 μ); *B. trifurcatum* (Eis. 1931) forma *nuda* Eisenack 1959 (52 μ); *B. trifurcatum* (Eis. 1931) forma *paucifurcatum* Eisenack 1959 (37–52 μ); *B. trifurcatum* (Eis. 1931) subsp. *consonum* Sannemann 1955 (150 μ); *B. trifurcatum* subsp. *procerum* Sannemann 1955 (120 μ); *B. triplicativum*

(Timofiev 1959) comb. nov. (62–73 μ); *B. truncatum* (Staplin 1961) comb. nov. (formerly *Multiplicisphaeridium*) (28–38 μ); *B. tuberatum* (Downie 1958) comb. nov. (15–30 μ); *B. tuberosum* (Sannemann 1955) comb. nov. (125 μ).

B. venustum (Sannemann 1955) comb. nov. (150 μ); *B. vigivitispinum* (Staplin 1961) comb. nov. (formerly *Micrhystridium*) (24 μ); *B. zonale* (Timofiev 1959) comb. nov. (93–106 μ).

Remarks. The seventy-nine species attributed to *Archaeohystrichosphaeridium* by Timofiev (1959) have not been reattributed to *Baltisphaeridium* here (although all are capable of such reattribution) in view of the possibility of a redefinition of the genus. Sannemann (1955) refers to a species, *Hystrichosphaeridium saalfieldensis* Eisenack, of which no description could be located: this species is therefore omitted from consideration. The species *Baltisphaeridium lewisi*, *B. paucispinosum*, and *B. sericum* were published as names accompanying figures (Deunff 1956): since no text descriptions have been yet published, their validity is doubtful.

Other species (*Post-Palaeozoic*). *Baltisphaeridium armatum* (Deflandre 1937) comb. nov. (25 × 18–20 μ); *B. asteroideum* (Maslov 1956) comb. nov. (20–28 μ); *B. biformoides* (Eisenack 1954) comb. nov. (50–67 μ); *B. brevispinosum* Pastiels 1948 non Eisenack 1931 (40–55 μ × 22–25 μ).

B. centrocarpum (Deflandre and Cookson 1955) Gerlach 1961 (54–80 μ); *B. claviculorum* (Deflandre 1938) comb. nov. (30 μ); *B. claviferum* (Wilkinson 1849) comb. nov. (*c.* 100 μ); *B. clavigerum* (Deflandre 1937) comb. nov. (*c.* 45 μ); *B. colligerum* (Deflandre and Cookson 1955) comb. nov. (33 μ).

B. danicum (W. Wetzel 1952) comb. nov. (36–72 μ); *B. densicomatum* (Maier 1959) Gerlach 1961 (53–95 × 86–88 μ); *B. dictyophorum* (Cookson and Eisenack 1958) comb. nov. (71 μ); *B. difforme* (Pritchard 1845) comb. nov. (*c.* 30 μ); *B. divergens* (Eisenack 1954) comb. nov. (52–83 μ); *B. downiei* Sarjeant 1960*a* (32–40 × 38–46 μ); *B. echinoides* (Maier 1959) comb. nov. (70–80 μ); *B. ehrenbergi* (Deflandre 1947) Sarjeant 1961 (42–46 μ).

B. ferox (Deflandre 1937) comb. nov. (46–120 μ); *B. fimbriatum* (White 1842) Sarjeant 1959 (31–77 μ); *B.* cf. *fimbriatum* (White 1842), Valensi 1955 (34–35 μ); *B.* cf. *fimbriatum* (White 1842), Sarjeant 1960*b* (dimensions not obtained); *B. flosculus* (Deflandre 1937) comb. nov. (38–45 μ); *B. geometricum* (Pastiels 1948) comb. nov. (44–60 μ); *B. gilsonii* (Kufferath 1950) comb. nov. (formerly *Micrhystridium*) (30 μ); *B. gramulosum* (Deflandre 1937) Sarjeant 1962*a* (33–55 × 18–26 μ).

B. heteracanthum (Deflandre and Cookson 1955) comb. nov. (56–107 μ); *B.* cf. *hirsutoides* (Eisenack 1939) Gocht 1952 (*c.* 80 μ); *B. hirsutum* (Ehrenberg 1838) comb. nov. (35–46 μ); *B. hirsutum* (Ehr. 1838) forma *minor* O. Wetzel 1933 (16–28 μ); *B. hirsutum* (Ehr. 1838) forma *varians* O. Wetzel 1933 (35–76 × 25–60 μ); *B. hirsutum* subsp. *amplum* W. Wetzel 1955 (96 μ): *B.* cf. *hirsutum* (Ehr. 1838) Pastiels 1948 (35–40 μ); *B.* cf. *hirsutum* (Ehr. 1838) Cookson, 1953 (26–44 μ); *B.* cf. *hirsutum* (Ehr. 1838), Cookson and Eisenack 1958 (dimensions not stated); *B. horridum* (Deflandre 1937) comb. nov. (55–57 μ); *B. huguonioti* (Valensi 1955) comb. nov. (29–33 × 25–29 μ).

B. iaculigerum Klement 1960 (29–35 μ); *B. intermedium* (O. Wetzel 1933) comb. nov. (dimensions not quoted); *B.* cf. *intermedium* (O. Wetzel 1933) Deflandre 1938 (30–35 μ); *B. inusitatum* Klement 1960 (52 μ); *B. lobospinosum* (Gocht in Weiler 1956) comb. nov. (90–95 μ); *B. longifurcatum* (Firtion 1952) comb. nov. (40–46 μ); *B. longofilum* (Maier 1959) comb. nov. (59 μ); *B. lumectum* Sarjeant 1960*a* (45–65 μ).

B. machaerophorum (Deflandre and Cookson 1955) Gerlach 1961 (41–54 μ); *B. malleoferum* (White 1842) comb. nov. (63–85 μ); *B. mariannae* (Philippot 1949) comb. nov. (*c.* 40 μ); *B. mixtispinosum* Klement 1960 (46–60 × 37–52 μ); *B. multifurcatum* (Deflandre 1937) Klement 1960 (45–65 μ); *B.* cf. *multifurcatum* (Defl. 1937), Firtion 1952 (40–60 μ); *B.* cf. *multifurcatum* (Defl. 1937), Klement 1960, (58–63 μ); *B. neptuni* Eisenack 1958 (40–60 μ).

B. oligacanthum (W. Wetzel 1952) comb. nov. (mean 72 μ); *B. oligacanthum* (W. Wet.) var., W. Wetzel 1952 (90 μ); *B. oligacanthum* (W. Wet. 1952) subsp. *complanatum* W. Wetzel 1952 (66–72 μ); *B. oligacanthum* (W. Wet.) subsp. *grandulatum* W. Wetzel 1952 (60 μ); *B. oligacanthum* (W. Wet. 1952) subsp. *stella* W. Wetzel 1952 (36–42 μ); *B. oligacanthum* (W. Wet. 1952) subsp. *velatum* W. Wetzel 1952 (60 μ).

B. palmatum (Deflandre and Courteville 1939) comb. nov. (*c.* 54 μ); *B.* cf. *palmatum* (Defl. and Court.

1939), Valensi 1955 (45 μ); *B. panniforme* Gerlach 1961 (46–68 × 53–105 μ); *B. parvispinum* [Deflandre 1937] (Cookson and Eisenack 1958) Klement 1960 (40–84 × 20–46 μ); *B. pattei* (Valensi 1948) Sarjeant 1960*a* (34–37 μ); *B. pectiniforme* Gerlach 1961 (32–42 μ); *B. pilosum* (Ehrenberg 1843) Sarjeant 1961 (33–60 μ); *B. pilosum* (Ehr. 1843) var. *longispinosum* Sarjeant 1961 (51 × 28 μ); *B. placacanthum* (Deflandre and Cookson 1955) comb. nov. (49–54 μ); *B. plicatum* (Maier 1959) comb. nov. (45 μ); *B. polytrichum* (Valensi 1947) Sarjeant 1960*a* (33–60 μ); *B. polytrichum* Downie 1957 non Valensi 1947 (40 μ); *B. pseudhystrichodinium* (Defl. 1937) comb. nov. (38–45 × 49–54 μ); *B. pseudhystrichodinium* (Defl. 1937) subsp. *magnum* W. Wetzel 1955 (98 μ+); *B.* cf. *pseudhystrichodinium* (Defl. 1937), Lejeune-Carpentier 1941 (dimensions similar to that species); *B.* cf. *pseudhystrichodinium* (Defl. 1937), Gocht 1952 (55 × 72 μ); *B.* cf. *M. pumile* (O. Wetzel 1932), Valensi 1948 (26–30 μ).

B. ramuliferum (Deflandre 1937) comb. nov. (35–45 μ); *B.* cf. *ramuliferum* (Defl. 1937), Gocht 1952 (63 × 50 μ); *B. reginaldi* (Mantell 1846) comb. nov. (?); *B. rehdense* (Maier 1959) comb. nov. (59–66 μ); *B. saturnium* (Maier 1959) comb. nov. (70 μ); *B. seminudum* (W. Wetzel 1952) comb. nov. (30–72 μ); *B. spiculatum* (White 1842) comb. nov. (*c.* 160 μ); *B. spinosum* (White 1842) comb. nov. (40–102 μ); *B. striolatum* (Defl. 1937) comb. nov. (40–58 μ); *B.* cf. *striolatum* (Defl. 1937), W. Wetzel 1952 (72 μ); *B. striatoconus* (Deflandre and Cookson 1955) comb. nov. (52–57 μ); *B. stimuliferum* (Defl. 1938) Sarjeant 1960*b* (20–26 μ).

B. tiara (Klumpp 1953) comb. nov. (44–68 μ); *B.* cf. *tiara* (Klumpp 1953), Deflandre and Cookson 1955 (44 × 58 μ); *B. triangulatum* Gerlach 1961 (36–60 × 33–48 μ); *B. tribuliferum* Sarjeant 1962*b* (53–62 × 48–58 μ); *B. tridactylites* (Valensi 1955) comb. nov. (40 × 33 μ); *B. trifurcatum* Pastiels 1948 non Eisenack 1931 (30–50 μ); *B.* cf. *trifurcatum* (Eis. 1931), Gocht 1952 (55 μ).

B. varispinosum Sarjeant 1959 (*c.* 48 μ); *B. vestitum* (Deflandre 1938) Sarjeant 1960*b* (38–70 μ); *B.* cf. *vestitum* (Defl. 1938), Deflandre 1941 (65 μ); *B. whitei* (Deflandre and Courteville 1939) Sarjeant 1959 (56–60 μ); *B. xanthiopyxides* (O. Wetzel 1933) Klement 1960 (28–30 × 10–12 μ).

Remarks. Baltisphaeridium spiralisetum de Wit 1943, of which descriptions have been given only in Dutch, is not treated. *Hystrichosphaeridium mensulum* (O. Wetzel 1933) is, from its description, referred to *Veryhachium*. *H. pterophorum* Deflandre and Courteville 1939 is transferred to *Cymatiosphaera*. *H. pumile* (O. Wetzel 1933) and *H.* cf. *pilosum* forma *nana* (O. Wetzel 1933) are transferred to *Micrhystridium*. The latter form, which cannot be considered comparable to *B. pilosum*, is considered probably conspecific with *Micrhystridium inconspicuum* and is therefore renamed *M.* cf. *inconspicuum*.

Genus MICRHYSTRIDIUM Deflandre 1937, emend.

Emended diagnosis. Hystrichospheres with spherical or oval shells not divided into fields or plates, bearing processes with closed tips, most often simple, rarely branching or ramifying, without distal connexions of any kind. The processes are generally of one type only. Mean and modal diameter of shell less than 20 μ.

Type species. Micrhystridium inconspicuum (Deflandre 1935) Deflandre 1937 (7–11 μ); Jurassic–Cretaceous.

Other species (*Palaeozoic*). *Micrhystridium albertensis* Staplin 1961 (18 μ); *M. angustum* Staplin 1961 (14–16 μ); *M. bacilliferum* Deflandre 1946 (8–10 μ); *M. bistchoensis* Staplin 1961 (*c.* 17 μ); *M. duodeciaster* (Staplin 1961) comb. nov. (formerly *Veryhachium*) (18 μ); *M. eatonensis* Downie 1959 (12–22 μ).

M. imitatum Deflandre 1942 (8–10 μ); *M. incertum* Deunff 1958 (6–7 μ); *M. mendax* Deflandre 1945 (11 μ); *M. micropolygonale* Stockmans and Willière 1961 (18 μ); *M. nannacanthum* Deflandre 1942 (10–14 μ); *M. parinconspicuum* Deflandre 1942 (9–13 μ); *M. parvispinum* Deflandre 1946 (9–12 μ); *M. parvispinum* Defl. 1946 forma *major* Deflandre 1946 (15 μ).

M. robustum Downie 1958 (10–12 μ); *M. shinetonensis* Downie 1958 (4–15 μ); *M. stellatum* Deflandre 1942 (11–16 μ); *M. stellatum* Deflandre 1942 var. *inflatum* Downie 1959; *M. tenuissimum* Deflandre

1945 (5 μ); *M. tenuissimum* Deflandre 1945 forma *major* Deflandre 1946 (10 μ); *M. tomaeeuse* Stockmans and Willière (10 μ).

Other species (*Post-Palaeozoic*). *Micrhystridium ambiguum* Deflandre 1937 (14–22 μ): *M.* cf. *ambiguum* Deflandre 1937, Cookson 1953 (13–20 μ); *M. arachnoides* Valensi 1953 (5–8 μ); *M.* cf. *arachnoides* Valensi 1953 (7–8 μ); *M. bigoti* Deflandre 1947 (13–25 × 12–22 μ); *M. biornatum* Deflandre 1937 (15–17 μ); *M. castaninum* Valensi 1953 (10 μ); *M. cometes* Valensi 1948 (11–19 μ).

M. deflandrei Valensi 1948 (11–19 μ); *M. densispinum* Valensi 1953 (11–13 μ); *M. echinoides* Valensi 1948 (10–17 μ); *M. echinoides* Valensi 1948 forma *minor* Valensi 1953 (7–10 μ); *M. filigerum* Valensi 1953 (10–13 μ); *M. fragile* Deflandre 1947 (7–20 μ); *M.* cf. *fragile* Deflandre 1947, Valensi 1953 (12–16 μ); *M. heteracanthum* Deflandre 1937 (8 μ).

M. inconspicuum (Defl. 1935) forma *bullosa* Valensi 1953 (7–10 μ); *M. inconspicuum* (Defl. 1935) forma *helios* Valensi 1953 (9–13 μ); *M.* cf. *inconspicuum* Deflandre 1935, O. Wetzel 1933 (= *Hystrichosphaera* cf. *pilosa* forma *nana*) (6–20 μ); *M.* cf. *inconspicuum* (Defl. 1935) Deflandre and Cookson 1955 (dimensions not quoted); *M.* cf. *inconspicuum* (Defl. 1935), Sarjeant 1960*b* (6–9 μ).

M. lagynophorum Valensi 1953 (13–18 μ); *M. leptothrix* Valensi 1953 (17–22 μ); *M. lucasi* Valensi 1953 (14–15 μ); *M. mastigophorum* Valensi 1948 (14 × 16 μ); *M.* cf. *mendax* Deflandre 1945, Sarjeant 1961 (11 μ); *M. multispinosum* Pastiels 1948 (*c.* 15 μ); *M. nannacanthum* Valensi 1953 non Deflandre 1942 (10 μ); *M. operosum* Deflandre 1937 (8·5–11 μ); *M. pachydermum* Deflandre and Cookson 1955; *M. piliferum* Deflandre 1937 (20–22 μ); *M. piveteaui* Valensi 1953 (19 × 18 μ); *M. polyedricum* Valensi 1948 (6 × 8 μ); *M. pumile* (O. Wetzel 1933) comb. nov. (12–20 μ).

M. rarispinum Sarjeant 1960*b* (8–15 μ); *M. recurvatum* Valensi 1953 (10–21 μ); *M. recurvatum* Valensi 1953 forma *brevispinosa* Valensi 1953 (12–14 μ); *M. recurvatum* Valensi 1953 forma *longispinosa* Valensi 1953 (13–14 μ); *M. recurvatum* Valensi 1953 forma *multispinosa* Valensi 1953 (14–15 μ); *M. recurvatum* Valensi 1953 forma *reducta* Valensi 1953 (11 μ); *M.* cf. *recurvatum* Valensi 1953, Valensi 1953 (8 μ); *M.* cf. *recurvatum* forma *multispinosa* Valensi 1953, Sarjeant 1960*b* (22 × 19 μ); *M. rhopalicum* Sarjeant 1962*b* (10–15 μ); *M. roquesi* Valensi 1948 (16 μ).

M. scutospinum Valensi 1953 (14 μ); *M. singulare* Firtion 1953 (14·5 × 18·5 μ); M. cf. *stellatum* Deflandre 1942, Valensi 1953 (up to 18 μ); *M.* cf. *stellatum* Deflandre 1942, Deflandre and Cookson 1955 (14–19 μ); ?*M. stellatum* Deflandre 1942, Sarjeant 1959 (*c.* 25 μ); *M. sydus* Valensi 1953 (5–7 μ); *M. tenuissimum* Valensi 1953 non Deflandre 1945 (5 μ); *M. variabile* Valensi 1953 (15–16 μ).

Remarks. The species of *Micrhystridium* having tubular spines, *M. fucosum* Valensi 1955 and *M. paulinae* Valensi 1953, are transferred to the genus *Hystrichosphaeridium* Deflandre 1937 emend. Eisenack 1958. The species having a shell surface divided by ridges into fields, *M. dictyophorum* Valensi 1953, *M. placophorum* Valensi 1948, *M. reticulatum* Deflandre 1937, and *M.* cf. *reticulatum* Deflandre 1937, Cookson 1953, are transferred to the genus *Cymatiosphaera* O. Wetzel 1933 emend. Deflandre 1954. *M. polyedricum* forma *reducta* Valensi 1953 is transferred to the genus *Veryhachium* and given specific status under the name *Veryhachium valensii* (Valensi 1953) comb. nov.

Genus VERYHACHIUM Deunff (1954) 1958, emend.

Emended diagnosis. A genus of hystrichospheres having polygonal or subpolygonal tests bearing a small number (in general 3–8) of hollow pointed spines with closed tips. Size of tests 10 μ to 40 μ, rarely smaller or greater.

Type species. Veryhachium trisulcum Deunff 1958; Ordovician.

Discussion. Distinction from *Michystridium* and *Baltisphaeridium* is based on the shape of the test and the number of spines. Polygonal and subpolygonal forms with nine or more spines are excluded unless it can be demonstrated that the additional spines are 'accidental' and that the individuals are members of a typical *Veryhachium* group (such forms are known in the Permian). *V. sedecimspinosum* Staplin 1961, with fifteen to

sixteen spines, and *V. duodeciaster* Staplin, with twelve spines, are therefore transferred respectively to *Baltisphaeridium* and to *Micrhystridium*. *V. ambiguum* Deunff is stated to have nine processes: unless it can be shown that the extra spines are to be considered 'accidental', this species also should be transferred to *Baltisphaeridium*. Certain species hitherto placed in *Micrhystridium* are transferred to *Veryhachium*: species are also transferred to this genus from *Baltisphaeridium*, *Hystrichosphaeridium*, and *Palaeotetradinium*.

Distinction between *Veryhachium* and *Estiastra* Eisenack depends on the relationship of the processes to the test. In the latter genus the bases of the processes meet at an acute angle and the test cannot be distinguished as a separate structure. In *Veryhachium*, on the other hand, the test is visibly distinct from the processes, although where the latter have wide, flaring bases they curve into the test walls and the point of junction cannot be accurately indicated. Eisenack has placed only one species in *Estiastra*; few others fit the diagnosis accurately. *V. centrigerum* Deunff 1957 accords well with *Estiastra*; the species *V. florigerum* Deunff 1957, *V. libratum* Deunff 1957, and *V. visbyense* (Eisenack 1959) all show transitional features. It is considered for the present best that all four species should be retained in *Veryhachium*, the boundary between the two genera appearing quite arbitrary.

Other species (*Palaeozoic*). *Veryhachium ambiguum* Deunff 1955; *V. asymmetricum* Deunff 1954; *V. bacifer* (Eisenack 1935) Deunff 1954; *V. balticum* (Eis. 1951) Deunff 1954; *V. brevitispinosum* Staplin 1961; *V. bulbiferum* (Deflandre 1944) Deunff 1954; *V. centrigerum* Deunff 1957; *V. ? clava* Deunff 1958; *V. crucistellatum* Deunff 1955.

V. eisenacki Deunff 1954; *V. europaeum* Stockmans and Willière 1961; *V. exasperatum* Deunff 1955; *V. florigerum* Deunff 1957; *V. formosum* Stockmans and Willière 1961; *V. furcillatum* Deunff 1955; *V. geometricum* (Deflandre 1944) Deunff 1954; *V. hebetatum* Deunff 1957; *V. heterogonum* Deunff 1955.

V. irregulare Jekhowsky 1961; *V. irregulare* Jekhowsky 1961 forma *pyrula* Jekhowsky 1961; *V. irregulare* Jekhowsky 1961 forma *subhexahedron* Jekhowsky 1961; *V. irregulare* Jekhowsky 1961 forma *subtetraedron* Jekhowsky 1961; *V. lairdi* (Deflandre 1946) Deunff 1954; *V. ledanoisi* Deunff 1957; *V. libratum* Deunff 1957.

V. ? macroceras Deunff 1958; *V. mamillatum* Deunff 1954; *V. minor* Staplin 1961; *V. minutum* Downie 1958; *V. octoaster* Staplin 1961; *V. oligospinosum* (Eisenack 1934) Deunff 1954; *V. polyaster* Staplin 1961; *V. reductum* (Deunff 1958) Jekhowsky 1961; *V. remotum* Deunff 1955; *V. rhomboidium* Downie 1959; *V. riburgense* Brosius and Bitterli 1961 (pars).

V. staurasteroides (Deflandre 1942) Deunff 1954; *V. stelligerum* Deunff 1957; *V. stelligerum* Deunff var. *robustum* Deunff; *V. tetraedron* Deunff 1954*c*; *V. tetraedron* var. *wenlockium* Downie 1959; *V. trispinosum* (Eisenack 1938) Deunff 1954; *V. trisulcum* Deunff var. *venetum* Deunff 1958; *V. visbyense* (Eisenack 1959).

Remarks. The species *Veryhachium asymmetricum*, *V. eisenacki*, *V. mamillatum*, and *V. tetraedron* were published as names accompanying figures (Deunff 1954); since no text descriptions have yet been published, their validity is doubtful.

Other species. (*Post-Palaeozoic*). *Veryhachium hyalodermum* (Cookson 1956) comb. nov. (formerly *Palaeotetradinium*); *V. mensulum* (O. Wetzel 1933) comb. nov.; *V. tetraxis* (Sarjeant 1960*b*) comb. nov. (formerly *Micrhystridium*); *V. valensii* (Valensi 1953) comb. nov. (= *Micrhystridium polyedricum* forma *reducta* Valensi 1953).

Genus LEIOSPHAERIDIA Eisenack 1958, emend.

Emended diagnosis. Spherical to ellipsoidal bodies without processes, often collapsed or

folded, with or without pylomes. Walls granular, punctate or unornamented; thin. Without divisions into fields and without transverse or longitudinal furrows or girdles.

Type species. Leiosphaeridia baltica Eisenack 1958; Ordovician.

Discussion. Eisenack's diagnosis is emended to exclude reference to colour, since this is considered to reflect degree of staining by humic substances rather than any intrinsic difference. Investigations have shown that single species of fossil microplankton can exhibit great variation in colour with provenance, and that colour modification can result from laboratory treatment with oxidizing solutions. The species described under the invalid names *Protoleiosphaeridium* and *Leiosphaeridium* are transferred to this genus.

Other species (*Palaeozoic*). *Leiosphaeridia aurata* (Deflandre 1945) Eisenack 1958; *L. cambriense* (Timofiev 1959) comb. nov.; *L. conglutinata* (Timofiev 1959) comb. nov.; *L. cryptogranulosa* (Staplin 1961) comb. nov.; *L. diaphania* (Staplin 1961) comb. nov.; *L. eisenackia* (Timofiev 1959) comb. nov.; *L. fastigatirugosa* (Staplin 1961) comb. nov.; *L. faveolata* (Timofiev 1959) comb. nov.; *L. fragile* Downie 1958.

L. granulata (Eisenack 1938) Eisenack 1958; *L. granulifera* (Staplin 1961) comb. nov.; *L. granulosa* (Staplin 1961) comb. nov.; *L. iudefinita* (Timofiev 1959) comb. nov.; *L. major* (Staplin 1961) comb. nov.; *L. megacystis* (Eisenack 1937) Eisenack 1958; *L. microcystis* (Eis. 1937) Eisenack 1958; *L. microgranulifera* (Staplin 1961) comb. nov.; *L. microsaetosa* (Staplin 1961) comb. nov.; *L. minuta* (Staplin 1961) comb. nov.; *L. nervata* (Timofiev 1959) comb. nov.; *L. orbiculata* (Staplin 1961) comb. nov.

L. papillata (Staplin 1961) comb. nov.; *L. reticulata* (Eisenack 1938) Eisenack 1958: *L. parvigranulosa* (Staplin 1961) comb. nov.; *L. retigera* (Deflandre 1945) Eisenack 1958; *L. sorediforme* (Timofiev 1959) comb. nov.; *L. tenuissima* Eisenack 1958; *L. voigti* Eisenack 1958; *L. wenlockia* Downie 1959; *L. winani* (Timofiev 1959) comb. nov.

Other species (*Post-Palaeozoic*). *Leiosphaeridia aptiana* Eisenack 1958; *L. chytroeides* Sarjeant 1962*b*; *L.* cf. *granulata* Eisenack 1938, Gocht 1952; *L. hyalina* (Deflandre 1941) comb. nov.; *L.* cf. *microcystis* (Eis. 1937), Valensi 1953; *L.* cf. *reticulata* Eisenack 1938, Gocht 1952; *L. similis* Cookson and Eisenack 1960; *L. scrobiculata* (Deflandre and Cookson 1955) Eisenack 1958.

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